(TRANSLATION)

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[Indication of Official Fee]

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[Document]	Specification	1
[Document]	Drawings	1
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[Name of Document] SPECIFICATION

[Title of the Invention] METHOD FOR PRODUCING LIQUID CRYSTAL DISPLAY DEVICE

[Claims]

[Claim 1]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light between a pair of substrates having been disposed as being opposed to each other; and

polymerizing the polymerizable component by irradiating the liquid crystal with light of a prescribed luminance at a prescribed temperature for a prescribed irradiating time under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein at least one of the voltage, the temperature, the luminance and the irradiation time is controlled as a parameter to obtain prescribed optical characteristics.

[Claim 2]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light in a first concentration, a polymerization initiator in a second

concentration and a polymerization inhibitor in a third concentration, respectively, between a pair of substrates having been disposed as being opposed to each other; and

polymerizing the polymerizable component so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein at least one of the first to third concentrations is controlled as a parameter, whereby obtains desired optical characteristics.

[Claim 3]

A method for producing a liquid crystal display device as described in claim 1 or 2, wherein the parameter is controlled under feedback of a thickness of a cell or a height of a pillar spacer formed on one of the pair of substrates before and after injecting the liquid crystal.

[Claim 4]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light between a pair of substrate having been disposed as being opposed to each other; and

polymerizing the polymerizable component under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein the voltage is varied in each color of a color

filter layer.

[Claim 5]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with light between a pair of substrates having been disposed as being opposed to each other; and

polymerizing the polymerizable component by irradiating the liquid crystal with light under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein the light is radiated by scanning a surface of the substrate using a linear light source.

[Detailed Description of the Invention]

[0001]

[Technical field to which invention belongs]

The present invention relates to a method for producing a liquid crystal display device, in which a pretilt angle and a tilt direction upon application of a voltage of liquid crystal molecules are controlled by using a polymer.

[0002]

[Prior Art]

In a liquid crystal display device of a multi-domain vertical alignment mode (MVA-LCD), a liquid crystal having negative dielectric anisotropy is vertically aligned, and the alignment direction of the liquid crystal upon application of a voltage is controlled to certain directions in pixels by utilizing an alignment controlling structure, such as linear protrusions and slits provided on a substrate, without rubbing.

[0003]

An MVA-LCD has such an advantage that it has excellent viewing angle characteristics in comparison to a liquid crystal display device of a TN mode, but it disadvantageously exhibits a low white luminance and low luminosity. The disadvantages are caused by such a mechanism that the area occupied by the alignment controlling structure forms segmentation boundaries in alignment of the liquid crystal, and the area is viewed with low luminosity to lower the light transmittance of the entire

pixels. In order to remove the disadvantages, the interval of the alignment controlling structure is sufficiently broadened. In this case, however, a prolonged period of time is required for stabilizing the alignment of the liquid crystal due to the small amount of the alignment controlling structure for controlling the alignment, whereby the response time is prolonged.

[0004]

In order to obtain an MVA-LCD having a high luminance and a short response time, it has been proposed that an alignment direction of a liquid crystal upon driving is controlled by using a polymer. In this method, a liquid crystal material obtained by mixing a liquid crystal and a monomer (polymerizable component) capable of being polymerized with heat or light is sealed between two substrates. The monomer is polymerized by irradiating the liquid crystal layer with UV light in a state where the liquid crystal molecules are tilted by applying a prescribed voltage between the substrates, so as to form a polymer. A liquid crystal layer controlled to a prescribed alignment direction and a prescribed pretilt angle is thus obtained even after removing the applied voltage, owing to the polymer formed in the vicinity of the surfaces of the substrates. Accordingly, a rubbing treatment of an alignment film can be omitted.

[0005]

[Patent Document 1]

JP-A-7-5444

[Patent Document 2]

JP-A-2001-33767

[Patent Document 3]

JP-A-5-158020

[0006]

[Problems to be Solved by the Invention]

However, it has been found in the liquid crystal display device produced by using the method of controlling the alignment direction of the liquid crystal molecules upon driving with a polymer that fluctuation in thickness of the cells largely influences the optical characteristics. Specifically, the cell thickness influences the optical characteristics in both cases upon polymerizing the polymer and upon practically driving the device, and therefore, such problems arise in that fluctuation in optical characteristics is increased in comparison to a device produced without polymerization, and luminance unevenness is liable to occur due to the luminance distribution of the UV light or the temperature distribution upon polymerizing the monomer.

[0007]

The conventional liquid crystal display devices also have the following problems.

(1) The optical characteristics, such as the γ

characteristics and the black luminance, are fluctuated upon changing the materials for the color filter layer and the alignment film, whereby the driving circuit is necessarily modified.

(2) A distribution in luminance occurs within the panel due to influences of wiring resistance, which is recognized as unevenness in luminance.

(3) The transmittance with respect to the birefringence of the liquid crystal is different by the colors of the color filter, so as to cause coloration in halftone.

[0008]

A liquid crystal display device is demanded to have bright display without unevenness, high speed response, less color change in half tone, and constant optical characteristics, such as the γ characteristics and the black luminance, from the standpoint of mass production.

[0009]

An object of the invention is to provide a method for producing a liquid crystal display device that provides good display characteristics.

[0010]

[Means for Solving the Problem]

The aforementioned objects of the invention can be attained by a method for producing a liquid crystal display device containing steps of: sealing a liquid crystal containing

a polymerizable component capable of being polymerized with heat or light between a pair of substrates having been disposed as being opposed to each other; and polymerizing the polymerizable component by irradiating the liquid crystal with light of a prescribed luminance at a prescribed temperature for a prescribed irradiating time under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules, setting at least one of the voltage, the temperature, the luminance and the irradiation time as a parameter to obtain prescribed optical characteristics.

[0011]

[Embodiments of Carrying out the Invention]

The method for producing a liquid crystal display device according to one embodiment of the invention will be described with reference to Figs. 1 to 7. In this embodiment, at least one of a voltage, a temperature and a luminance and a radiation time of UV light thus radiated is appropriately controlled as a parameter upon polymerizing a monomer to form a polymer, whereby the desired optical characteristics, such as the γ characteristics and the black luminance (black transmittance), are obtained. The voltage may be controlled, for example, within a range of 0.1 V to 100 V. The temperature may be controlled, for example, within a range of -30°C to 250°C. The luminance may be controlled, for example, within a range of

1 mW/cm^2 to 10,000 mW/cm^2. The radiation time may be controlled, for example, within a range of 1 msec to 24 hours.

[0012]

In this embodiment, at least one of a concentration of a polymerizable component, a concentration of a polymerization initiator and a concentration of a polymerization inhibitor is appropriately controlled as a parameter, whereby the desired optical characteristics are obtained. The concentration of the polymerizable component may be controlled, for example, within a range of 0.001% to 10% by weight. The concentration of the polymerization initiator may be controlled, for example, within a range of 0.0001% to 10% by weight.

[0013]

In this embodiment, a thickness of a cell or a height of a pillar spacer is measured before and after injecting a liquid crystal, and the parameters are controlled under feedback of the measured value. According to the procedures, a pretilt angle, i.e., T-V characteristics, of liquid crystal molecules can be controlled, whereby the optical characteristics, such as the γ characteristics and the black luminance, can be maintained constant in each liquid crystal display device.

In this embodiment, an applied voltage is varied in each color (each pixel) of a color filter layer, or a radiation amount of UV light radiated on a liquid crystal is changed by appropriately controlling an UV light transmittance of a color

filter layer, upon polymerizing a monomer. According to the procedures, the T-V characteristics can be appropriately controlled to suppress coloration in halftone.

[0014]

In this embodiment, a luminance distribution within a panel is previously measured, and an applied voltage (or in alternative, an UV light radiation amount or a temperature) upon polymerizing a monomer is varied in each region of the panel. For example, the applied voltage is increased in a region where the luminance is low. According to the procedures, the luminance distribution can be compensated to obtain a liquid crystal display device having less unevenness in luminance.

In this embodiment, upon polymerizing a monomer, the panel surface was irradiated by scanning thereon with UV light by using a linear light source. UV light is radiated by scanning in a direction within a panel. According to the procedures, UV light can be uniformly radiated within the panel to produce a liquid crystal display device having less unevenness in luminance. Further, the aforementioned compensation can be easily carried out in the scanning direction.

[0015]

According to the embodiment, the optical characteristics, such as the γ characteristics and the black luminance, can be made constant in each panel, and the optical characteristics can be arbitrarily controlled in a state of the panel. Therefore,

such a liquid crystal display device with high display quality can be obtained that exhibits no coloration in halftone and less luminance distribution within the panel.

[0016]

The embodiment will be described in more detail with reference to the following specific examples.

(Example 1)

TFT elements, a drain bus line, a gate bus line, a pixel electrode and other necessary components were formed on one substrate. A color filter layer, a common electrode and other necessary components were formed on another substrate. Both the substrates were attached with spacers each having a diameter of 4 μm intervening therebetween to produce a blank cell. A liquid crystal composition containing a photopolymerizable or thermally polymerizable component was injected in the blank cell to produce a liquid crystal panel. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with 0.3% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.). Plural liquid crystal panels thus produced were subjected to polymerization of the polymerizable component under the following conditions, and the following results were obtained.

[0017]

(1) While an alternating current voltage of 12 to 20

V was applied between the common electrode and the storage capacitor bus line of the liquid crystal panel, the panel was irradiated with UV light to polymerize the polymerizable component. Fig. 1 is a graph showing variation of the optical characteristics depending on the voltage applied on polymerization. The abscissa indicates the voltage (V) applied on polymerization, and the ordinate indicates the γ value and the black transmittance (%). In the graph, solid diamonds indicate the γ value, and hollow squares indicate the black transmittance. As shown in Fig. 1, the γ value and the black transmittance of the liquid crystal display device vary depending on the voltage applied on polymerization. Therefore, it is understood that a liquid crystal display device having the desired optical characteristics, such as the γ value and the black transmittance, can be obtained by appropriately controlling the voltage applied on polymerization.

[0018]

(2) While an alternating current voltage of 17 V was applied between the common electrode and the storage capacitor bus line of the liquid crystal panel, and the temperature was controlled, the panel was irradiated with UV light to polymerize the polymerizable component. Fig. 2 is a graph showing variation of the optical characteristics depending on the temperature on polymerization. The abscissa indicates the temperature (°C) on polymerization, and the ordinate indicates

the γ value and the black transmittance (%). In the graph, solid diamonds indicate the γ value, and hollow squares indicate the black transmittance. As shown in Fig. 2, the γ value and the black transmittance of the liquid crystal display device vary depending on the temperature on polymerization. Therefore, it is understood that a liquid crystal display device having the desired optical characteristics, such as the γ value and the black transmittance, can be obtained by appropriately controlling the temperature on polymerization.

[0019]

(3) While an alternating current voltage of 18 V was applied between the common electrode and the storage capacitor bus line of the liquid crystal panel, the panel was irradiated with UV light for a prescribed period of time to polymerize the polymerizable component. Fig. 3 is a graph showing variation of the optical characteristics depending on the radiation time of UV light. The abscissa indicates the radiation time (sec), and the ordinate indicates the γ value and the black transmittance (%). In the graph, solid diamonds indicate the γ value, and hollow squares indicate the black transmittance. As shown in Fig. 3, the γ value and the black transmittance of the liquid crystal display device vary depending on the radiation time of UV light. Therefore, it is understood that a liquid crystal display device having the desired optical characteristics, such as the γ value and the

black transmittance, can be obtained by appropriately controlling the radiation time of UV light.

[0020]

(Example 2)

TFT elements, a drain bus line, a gate bus line, a pixel electrode and other necessary components were formed on one substrate. A color filter layer, a common electrode and other necessary components were formed on another substrate. Both the substrates were attached with spacers each having a diameter of 4 μm intervening therebetween to produce a blank cells. Plural liquid crystal panels were produced by using the blank cell.

[0021]

(1) A liquid crystal component containing a photopolymerizable or thermally polymerizable component was injected in the blank cells to produce plural liquid crystal panels. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with 0.1 to 0.5% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.). While an alternating current voltage of 18 V was applied between the common electrode and the storage capacitor bus line of the liquid crystal panel, the panel was irradiated with UV light for a prescribed period of time to polymerize the polymerizable component. Fig. 4 is a graph showing variation of the optical

characteristics depending on the concentration of the polymerizable component. The abscissa indicates the concentration of the polymerizable component (% by weight), and the ordinate indicates the γ value and the black transmittance (%). In the graph, solid diamonds indicate the γ value, and hollow squares indicate the black transmittance. As shown in Fig. 4, the γ value and the black transmittance of the liquid crystal display device vary depending on the concentration of the polymerizable component. Therefore, it is understood that a liquid crystal display device having the desired optical characteristics, such as the γ value and the black transmittance, can be obtained by appropriately controlling the concentration of the polymerizable component.

[0022]

(2) A liquid crystal component containing a photopolymerizable or thermally polymerizable component was injected in the blank cells to produce plural liquid crystal panels. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with from 0.3% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.) and from 0.1 to 0.5% by weight based on the total polymerizable component of a polymerization initiator. While an alternating current voltage of 18 V was applied between the common electrode and the storage capacitor bus line of the liquid crystal panel,

the panel was irradiated with UV light for a prescribed period of time to polymerize the polymerizable component. As a result, it is found that the γ value and the black transmittance of the liquid crystal display device vary depending on the concentration of the polymerization initiator. Therefore, it is understood that a liquid crystal display device having the desired optical characteristics, such as the γ value and the black transmittance, can be obtained by appropriately controlling the concentration of the polymerization initiator.

[0023]

(Example 3)

TFT elements, a drain bus line, a gate bus line, a pixel electrode and other necessary components were formed on one substrate. A color filter layer, a common electrode and other necessary components were formed on another substrate. Both the substrates were attached with spacers each having a diameter of 4 μm intervening therebetween to produce a blank cell. A liquid crystal composition containing a photopolymerizable component was injected in the blank cell to produce a liquid crystal panel. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with 0.3% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.). The liquid crystal panel thus produced was measured for the thickness of the cell. While an alternating current voltage

of 18 V was applied between the common electrode and the storage capacitor bus line of the liquid crystal panel, the panel was irradiated with UV light to polymerize the polymerizable component. Fig. 5 is a graph showing variation of the optical characteristics depending on the thickness of the cell. The abscissa indicates the thickness of the cell (μm), and the ordinate indicates the γ value and the black transmittance (%). In the graph, solid diamonds indicate the γ value, and hollow squares indicate the black transmittance. As shown in Fig. 5, the γ value and the black transmittance of the liquid crystal display device vary depending on the thickness of the cell. Therefore, it is understood that a liquid crystal display device having the desired optical characteristics, such as the γ value and the black transmittance, can be obtained by controlling the respective parameters under feedback of the measured thickness of the cell to the aforementioned examples.

[0024]

(Example 4)

TFT elements, a drain bus line, a gate bus line, a pixel electrode and other necessary components were formed on one substrate. A color filter layer, a common electrode and other necessary components were formed on another substrate. Both the substrates were attached with spacers each having a diameter of 4 μm intervening therebetween to produce a blank cell. A liquid crystal composition containing a photopolymerizable

component was injected in the blank cell to produce a liquid crystal panel. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with 0.3% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.). While the red pixels, the green pixels and the blue pixels of the liquid crystal panel thus produced were applied with voltages of 9 V, 10 V and 7 V, respectively, the panel was irradiated with UV light to polymerize the polymerizable component. The voltage applied on polymerization thus varied by each color, whereby different T-V characteristics were obtained by each color.

[0025]

Fig. 6 is a graph showing variation of the luminance ratio depending on gradation of the liquid crystal display device produced in this example. Fig. 7 is a graph showing variation of the luminance ratio depending on gradation in an ordinary liquid crystal display device, in which the voltage applied on polymerization is 7 V in all the pixels. In the graphs, the abscissa indicates logarithm of the gradation (x/255), and the ordinate indicates logarithm of the luminance ratio. In the graphs, the curve r indicates the red pixel, the curve g indicates the green pixel, and the curve b indicates the blue pixel. As shown in Figs. 6 and 7, the difference in luminance ratio among the colors is relatively suppressed by compensating

the T-V characteristics by each color in the invention. Accordingly, a liquid crystal display device suppressed in coloration in halftone can be obtained.

[0026]

(Example 5)

TFT elements, a drain bus line, a gate bus line, a pixel electrode and other necessary components were formed on one substrate. A color filter layer, a common electrode and other necessary components were formed on another substrate. Both the substrates were attached with spacers each having a diameter of 4 μm intervening therebetween to produce a blank cell. A liquid crystal composition containing a photopolymerizable component was injected in the blank cell to produce a liquid crystal panel. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with 0.3% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.). The liquid crystal panel thus produced was measured for a luminance distribution in advance. While a high voltage was applied to a region with a low luminance, and a low voltage was applied to a region with a high luminance (with the voltage ranging from 7 to 9 V) based on the luminance distribution, the panel was irradiated with UV light to polymerize the polymerizable component. As a result, a liquid crystal display device having less luminance distribution within the panel can

be obtained.

[0027]

(Example 6)

TFT elements, a drain bus line, a gate bus line, a pixel electrode and other necessary components were formed on one substrate. A color filter layer, a common electrode and other necessary components were formed on another substrate. Both the substrates were attached with spacers each having a diameter of 4 μm intervening therebetween to produce a blank cell. A liquid crystal composition containing a photopolymerizable component was injected in the blank cell to produce a liquid crystal panel. The liquid crystal composition was a negative liquid crystal (produced by Merck Japan Co., Ltd.) mixed with 0.5% by weight of an acrylic polymerizable component exhibiting nematic liquid crystallinity (produced by Merck Japan Co., Ltd.). While an alternating current voltage of 12 V was applied to the liquid crystal panel thus produced, the panel surface was uniformly irradiated by scanning thereon with UV light by using an ultrahigh pressure mercury linear light source to polymerize the polymerizable component. As a result, a liquid crystal display device having less unevenness in luminance due to illuminance distribution can be obtained.

[0028]

According to this embodiment described in the foregoing, the display characteristics can be improved in a liquid crystal

display device, in which the pretilt angle and the tilt direction upon application of a voltage of the liquid crystal molecules are controlled by utilizing a polymer material obtained by polymerization under light or heat, whereby unevenness in optical characteristics in each panel can be reduced.

[0029]

The invention is not construed as being limited to the aforementioned embodiment, and various changes and modifications may be made therein.

For example, while such a liquid crystal device has been exemplified as a device that contains a color filter layer formed on a counter substrate disposed as facing a TFT substrate, the invention is not limited thereto and can be applied to a liquid crystal display device having a so-called CF-on-TFT structure, in which a color filter layer is formed on a TFT substrate.

[0030]

A method for producing a liquid crystal display device according to the embodiment of the present invention as described above is summarized as follows.

[Appendix 1]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light between a pair of substrates having been disposed as being opposed to

each other; and

polymerizing the polymerizable component by irradiating the liquid crystal with light of a prescribed luminance at a prescribed temperature for a prescribed irradiating time under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein at least one of the voltage, the temperature, the luminance and the irradiation time is controlled as a parameter to obtain prescribed optical characteristics.

[0031]

[Appendix 2]

A method for producing a liquid crystal display device as described in appendix 1, wherein the voltage is controlled within a range of 0.1 V to 100 V.

[0032]

[Appendix 3]

A method for producing a liquid crystal display device as described in appendix 1 or 2, wherein the temperature is controlled within a range of -30°C to 250°C.

[0033]

[Appendix 4]

A method for producing a liquid crystal display device as described in any of appendixes 1 to 3, wherein the luminance is controlled within a range of 1 mW/cm^2 to 10,000 mW/cm^2.

[0034]

[Appendix 5]

A method for producing a liquid crystal display device as described in any of appendixes 1 to 4, wherein the radiation time is controlled within a range of 1 msec to 24 hours.

[0035]

[Appendix 6]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light in a first concentration, a polymerization initiator in a second concentration and a polymerization inhibitor in a third concentration, respectively, between a pair of substrates having been disposed as being opposed to each other; and

polymerizing the polymerizable component so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein at least one of the first to third concentrations is controlled as a parameter, whereby obtains desired optical characteristics.

[0036]

[Appendix 7]

A method for producing a liquid crystal display device as described in appendix 6, wherein the first concentration is controlled within a range of 0.001% to 10% by weight.

[0037]

[Appendix 8]

A method for producing a liquid crystal display device as described in appendix 6 or 7, wherein the second concentration is controlled within a range of 0.0001% to 10% by weight.

[0038]

[Appendix 9]

A method for producing a liquid crystal display device as described in any of appendixes 1 to 8, wherein the parameter is controlled under feedback of a thickness of a cell or a height of a pillar spacer formed on one of the pair of substrates before and after injecting the liquid crystal.

[0039]

[Appendix 10]

A method for producing a liquid crystal display device as described in any of appendixes 1 to 9 , wherein the parameter is controlled to compensate a luminance distribution within the panel.

[0040]

[Appendix 11]

A method for producing a liquid crystal display device as described in any of appendixes 1 to 10, wherein the optical characteristics include γ characteristics and a transmittance upon displaying black.

[0041]

[Appendix 12]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light between a pair of substrate having been disposed as being opposed to each other; and

polymerizing the polymerizable component under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein the voltage is varied in each color of a color filter layer.

[0042]

[Appendix 13]

A method for producing a liquid crystal display device comprising the steps of:

sealing a liquid crystal containing a polymerizable component capable of being polymerized with light between a pair of substrates having been disposed as being opposed to each other; and

polymerizing the polymerizable component by irradiating the liquid crystal with light under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules,

wherein the light is radiated by scanning a surface of the substrate using a linear light source.

[0043]

[Effect of the Invention]

As described in the foregoing, a liquid crystal display device providing good display characteristics can be realized.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

It is a graph showing variation of optical characteristics depending on a voltage applied on polymerization, which is a prerequisite of a method for producing a liquid crystal display device of Example 1 according to one embodiment of the invention;

[Fig. 2]

It is a graph showing variation of optical characteristics depending on a temperature on polymerization, which is a prerequisite of a method for producing a liquid crystal display device of Example 1 according to the one embodiment of the invention;

[Fig. 3]

It is a graph showing variation of optical characteristics depending on an irradiation time of UV light, which is a prerequisite of a method for producing a liquid crystal display device of Example 1 according to the one embodiment of the invention;

[Fig. 4]

It is a graph showing variation of optical characteristics depending on a concentration of a polymerizable component, which is a prerequisite of a method for producing a liquid crystal display device of Example 2 according to the one embodiment of the invention;

[Fig. 5]

It is a graph showing variation of optical characteristics depending on a thickness of a cell, which is a prerequisite of a method for producing a liquid crystal display device of Example 3 according to the one embodiment of the invention;

[Fig. 6]

It is a graph showing variation of a luminance ratio depending on gradation of a liquid crystal display device produced in Example 4 according to the one embodiment of the invention;

[Fig. 7]

It is a graph showing variation of a luminance ratio depending on gradation in an ordinary liquid crystal display device;

[Legend]

r, g, b curve

FIG.1

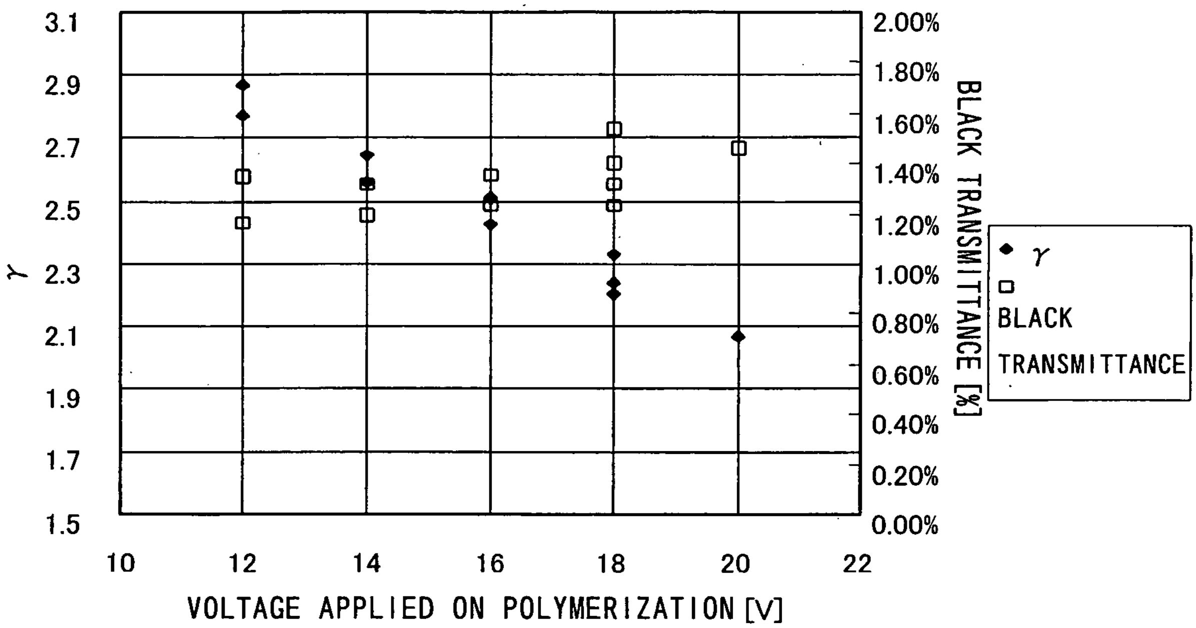

3.1
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
γ
2.00%
1.80%
1.60%
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
BLACK TRANSMITTANCE [%]
10
12
14
16
18
20
22
VOLTAGE APPLIED ON POLYMERIZATION [V]
γ
BLACK TRANSMITTANCE

FIG.2

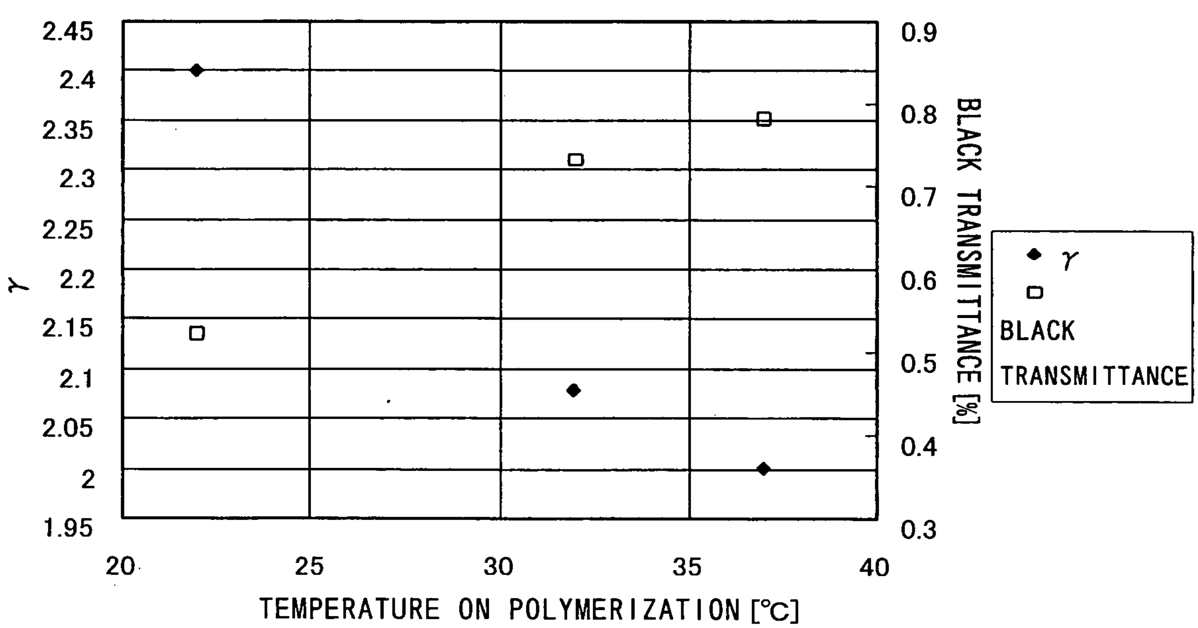
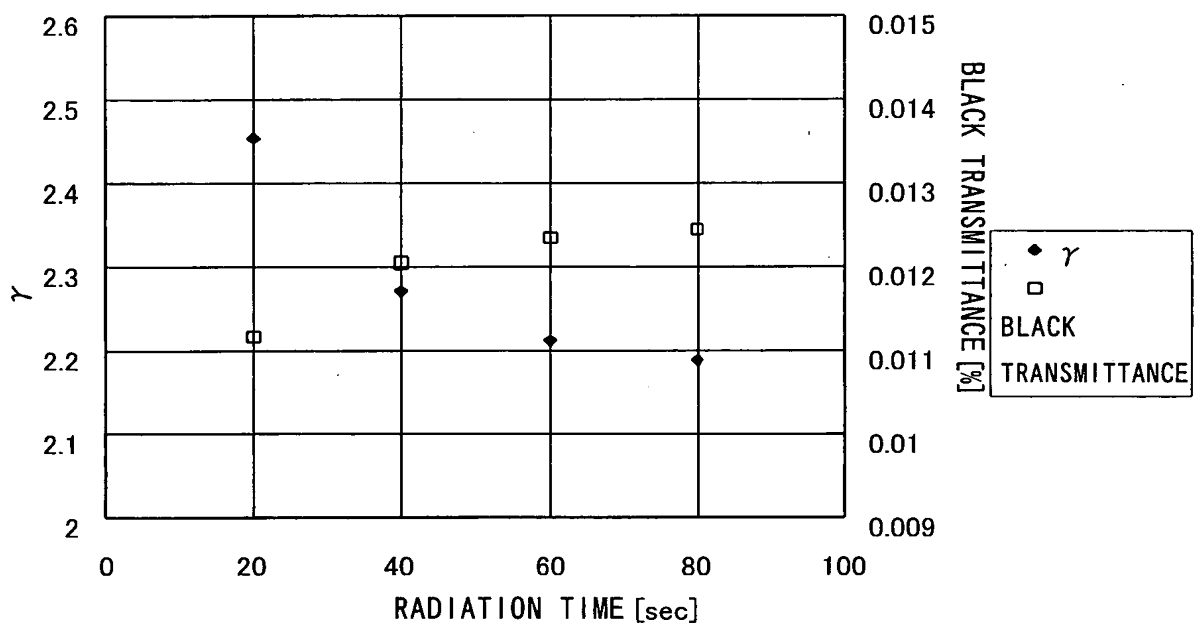
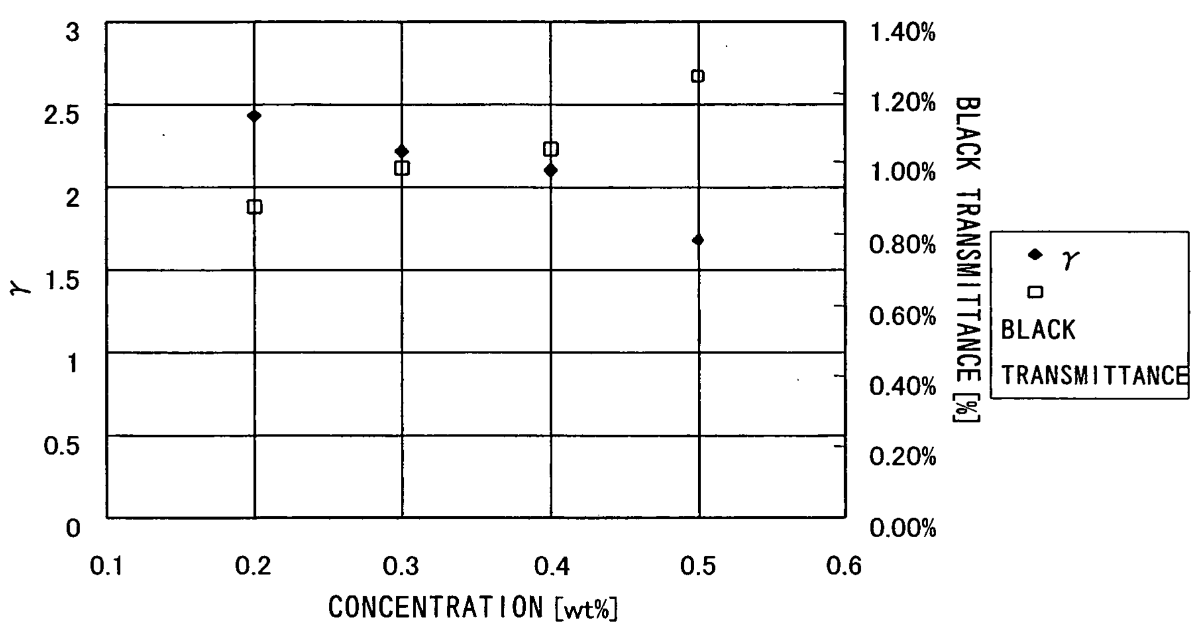

2.45
2.4
2.35
2.3
2.25
2.2
2.15
2.1
2.05
2
1.95
γ
0.9
0.8
0.7
0.6
0.5
0.4
0.3
BLACK TRANSMITTANCE [%]
20
25
30
35
40
TEMPERATURE ON POLYMERIZATION [℃]
γ
BLACK TRANSMITTANCE

FIG.3



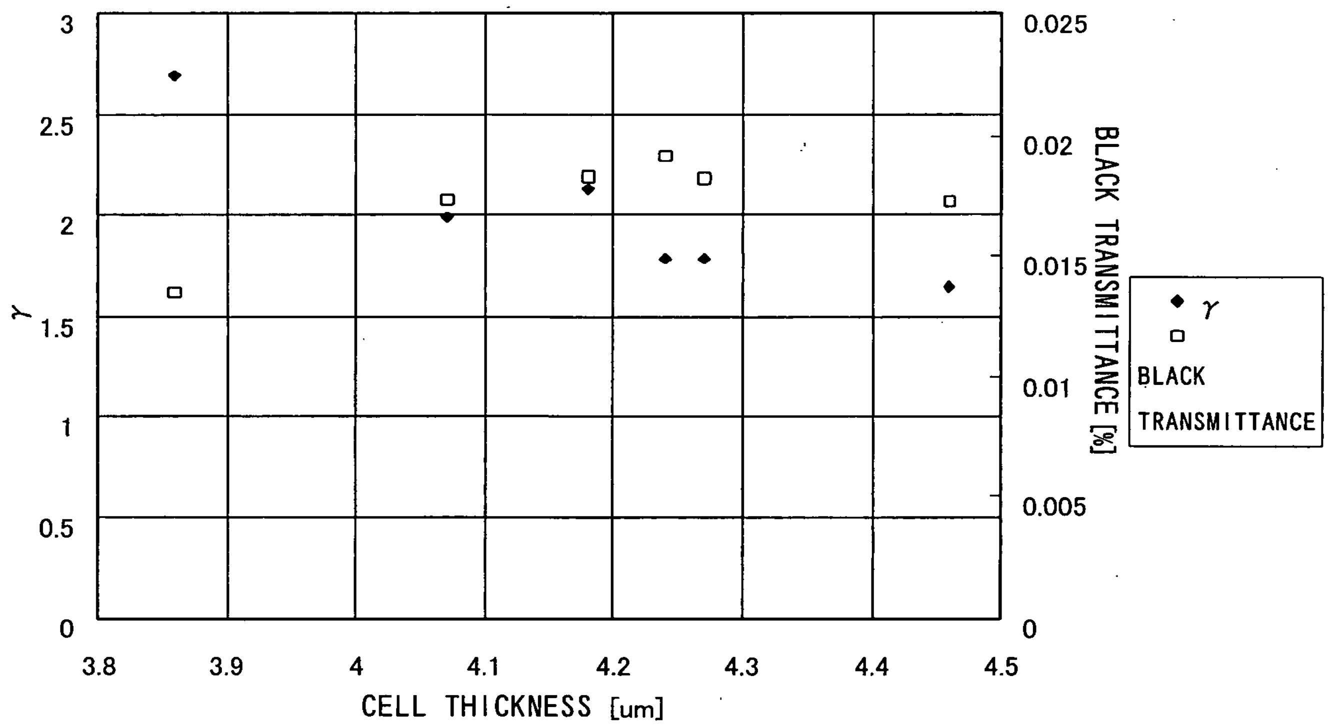
2.6
2.5
2.4
2.3
2.2
2.1
2
γ
0.015
0.014
0.013
0.012
0.011
0.01
0.009
BLACK TRANSMITTANCE [%]
0
20
40
60
80
100
RADIATION TIME [sec]
γ
BLACK TRANSMITTANCE

FIG.4



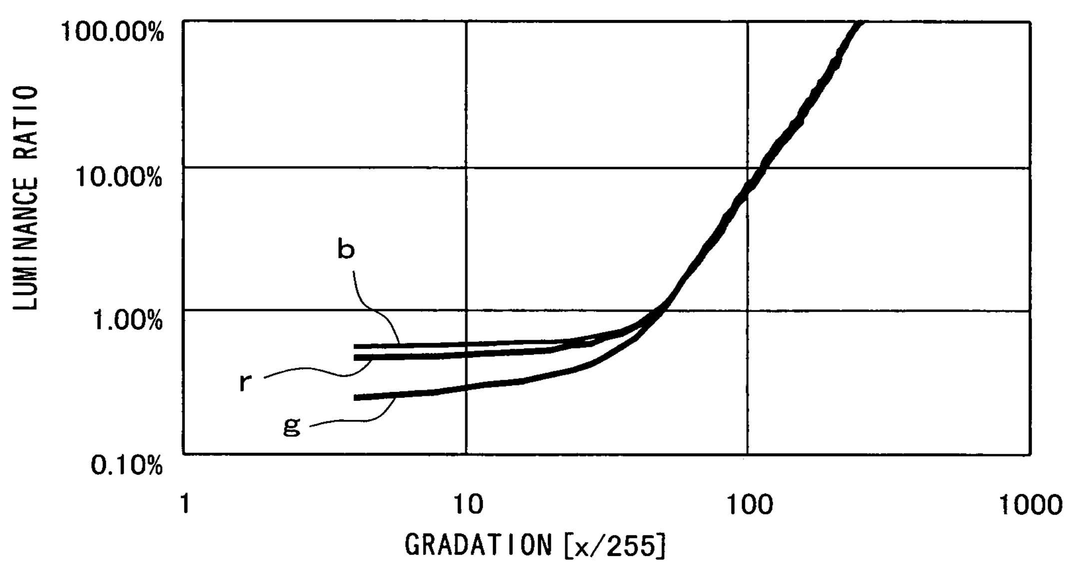
3
2.5
2
1.5
1
0.5
0
γ
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
BLACK TRANSMITTANCE [%]
0.1
0.2
0.3
0.4
0.5
0.6
CONCENTRATION [wt%]
γ
BLACK TRANSMITTANCE

FIG.5



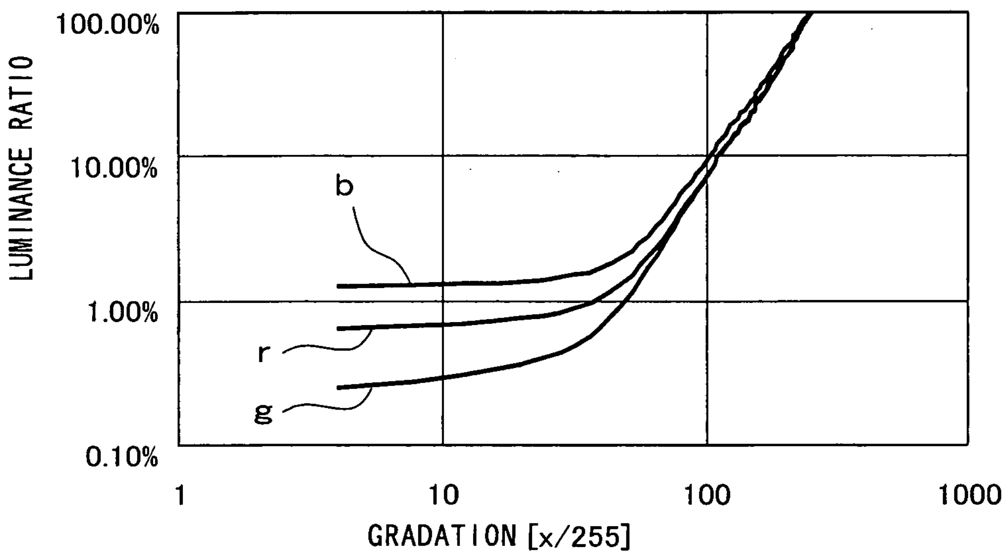
3
2.5
2
1.5
1
0.5
0
γ
0.025
0.02
0.015
0.01
0.005
0
BLACK TRANSMITTANCE [%]
3.8
3.9
4
4.1
4.2
4.3
4.4
4.5
CELL THICKNESS [um]
γ
BLACK TRANSMITTANCE

FIG.6



100.00%
10.00%
1.00%
0.10%
LUMINANCE RATIO
b
r
g
1
10
100
1000
GRADATION [x/255]

FIG.7


LUMINANCE RATIO
100.00%
10.00%
1.00%
0.10%
b
r
g
1
10
100
1000
GRADATION [x/255]

[Name of Document] ABSTRACT

[Summary]

[Problem] The present invention relates to a method for producing a liquid crystal display device, in which a pretilt angle and a tilt direction upon application of a voltage of liquid crystal molecules are controlled by using a polymer and is to provide a method for producing a liquid crystal display device that provides good display characteristics.

[Solving Means] The method for producing a liquid crystal display device includes steps of: sealing a liquid crystal containing a polymerizable component capable of being polymerized with heat or light between a pair of substrates having been disposed as being opposed to each other; and polymerizing the polymerizable component by irradiating the liquid crystal with light of a prescribed luminance at a prescribed temperature for a prescribed irradiating time under application of a prescribed voltage, so as to control a pretilt angle and a tilt direction of liquid crystal molecules, and at least one of the voltage, the temperature, the luminance and the irradiation time is set as a parameter to obtain prescribed optical characteristics.

[Selected Figure] Fig. 1